FRIDTJOF NANSEN, G.C.V.O., D.Sc., D.C.L., Ph.D., (1861–1930)

A Note on his Contributions to Neurology on the Occasion of the Centenary of his Birth

by

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"The most important thing in all research is not just the results, the final conclusions, but the research itself, the struggle to achieve the results. The fascinating thing is not so much to establish the relationship as to sense it and seek it."—*Fridtjof Nansen.*

Fig. 1. Fridtjof Nansen. A lithograph self-portrait, drawn in 1930 a few months before the artist's death.

IN ADDITION TO his many other talents (ski champion, explorer, geologist, oceanographer, politician, diplomat, humanitarian, university rector, Nobel Peace Prize winner), Fridtjof Nansen was a distinguished biologist and microscopist—especially in the field of neuro-anatomy.

Nansen's career

Fridtjof Nansen (Fig. 1) was born one hundred years ago in Sörkedalsveien in Norway, in the autumn of 1861; but he was of Danish descent through the families of both his father and his mother. Nansen's mother Adelaide was a daughter of an aristocratic Danish family, while his

father Baldur—a prominent lawyer, who was Adelaide's second husband —was descended from a former distinguished Mayor of Copenhagen. Fridtjof was the elder son of his mother's second marriage to Baldur Fridtjof Nansen, a second son (Alexander Christinius) being born a year after Fridtjof.

Fridtjof and his brother Alexander spent a considerable part of their boyhood together in outdoor adventures, in the course of which Fridtjof became such an accomplished skater and skier that he later won prizes in national competitions in both these sports. He also distinguished himself in scientific subjects at school, receiving prizes for natural sciences, mathematics and drawing. When Nansen entered the University of Christiania in Oslo in 1880, he elected to study zoology as his principal subject, but for a rather unusual reason: " I had a leaning to science; but to which science? Physics and Chemistry interested me most; but Zoology would be better, promising more fun, more hunting and outdoor life. So we went in for Zoology."

During his first year at the University, Nansen was advised by Professor Robert Collett to join a seal-hunting expedition, in order to study the biology of the Arctic seal at first hand.* Thus it was that in March 1882 Nansen—a twenty-year old freshman—set out on his first Arctic expedition into the Greenland Sea in the " Viking ", on a voyage that affected the whole course of his future life. On his return to Norway at the end of 1882, Nansen (on the recommendation of Professor Collett) was offered a curator's post at the Bergen Museum of Zoology—although he was still a first-year zoology student who had not yet passed a single examination in the subject. For the next six years, Nansen devoted himself to his microscope (purchased with a loan from his father) in the laboratories of the Museum, engaged on anatomical studies of the parasitic worms known as *Myzostomae* and on the neuro-histology of the primitive eel-worm *Myxine glutinosa.*

When Nansen entered the Bergen Museum its Director was D. C. Danielssen, a distinguished zoologist who had achieved an international reputation with his work on the pathology of leprosy; while one of his colleagues on the staff was Armauer Hansen, already famous for his isolation of the leprosy bacillus ten years before. As a result, the Bergen Museum was permeated with an atmosphere of devotion to research in which Nansen flourished. After four years of work, Nansen was advised by Danielssen to travel abroad to widen his scientific experience, and to modernize his histological techniques. After short visits to museums and laboratories in Germany and other parts of Southern Europe, Nansen now set off for Naples, to work for a year at the Marine Biological

* The scientific observations that he made on this voyage were not published until forty years later in *Among Bears and Seals* (1924), which contains the first statistical studies on the seal population, as well as 87 illustrations from Nansen's own hand.

Institute that had been set up there in 1874 by the German zoologist Anton Dohrn. While he was in Naples, Nansen took the opportunity of going to Pavia to work for a time with Camillo Golgi, so that he might learn the latter's technique of silver impregnation of nerve tissue for use in his study of the *Myzostomae* and of *Myxine glutinosa.*

Stimulated by these foreign contacts, Nansen pushed on apace with his research after his return to Bergen in 1887. Two years previously, he had been awarded the Joachim Friele gold medal for his study of the general anatomy and histology of the *Myzostomae*; and after his return from Italy, armed with his new knowledge of Golgi's methods, he made a more detailed study of the nervous system of this species, the results of which he incorporated into a thesis for which he received the degree of Doctor of Philosophy in April 1888. Most of Nansen's work in this field was published in the Bulletin of the Bergen Museum (*Bergens Museum Aarsberetning*), usually in English; and a chronological list of these and his other publications relating to neuro-anatomy will be found at the end of this article.

As a respite from his six years' devotion to laboratory work (" For six years I lived in a microscope ") Nansen now decided—to the horror of his colleagues and friends—to escape into the great outdoors by crossing Greenland on skis. In his Rectorial Address to the students of the University of St. Andrews in 1926, Nansen described the making of this momentous decision: " We had just finished a treatise on the nervous system, with the result that the author's own nervous system was over-strained and needed a little rest. Just then Master Irresponsible took advantage of a weak moment . . . and told me that the time had come to carry out our old plan of crossing Greenland. It would not take long, and we could soon return to the nervous system again with renewed vigour." No previous crossing of the Greenland ice-cap had yet been made, although there had been many unsuccessful and occasionally disastrous attempts, and so Nansen's proposal met with considerable opposition—including the refusal of a financial grant from the Government. Nonetheless undaunted, Nansen assembled a small expedition of six men and set off in May 1888—just one week after he had publicly defended his Ph.D. thesis on the neuro-anatomy of *Myxine glutinosa*, also against vigorous opposition. After a year of unremitting hardship this great enterprise achieved its goal, and the young Dr. Nansen returned to a hero's welcome in May 1889—aged twenty-eight years. He described the scientific results of this remarkable journey in *The First Crossing of Greenland*, the two large volumes of which appeared the following year; while his anthropological studies of the Greenland Eskimo were reported in *Eskimo Life.*

On his return from Greenland in 1889, Nansen resumed his anatomical research once more. He was appointed Curator of the Zoology Museum

in the University; but at the same time he organized the setting up of the first Marine Biological Station in Norway at his former locale in Bergen (opened in 1891), and a second at the University (opened in 1894). In addition to continuing his neuro-histological researches on the *Myzostomae* and on *Myxine glutinosa*, Nansen now undertook another great anatomical project for which he had been steadily assembling material all the while he was in Bergen. He had long wanted to make a systematic study of the anatomy and embryology of the whale, of which little was then known; and so, after taking up his appointment at the University, he began work on his collection of whale embryos with Professor G. A. Guldberg (then Professor of Anatomy in the University). Five years later, the results of their labours saw the light in their vast and authoritative *On the Development and Structure of the Whale*, which appeared in 1894—by which time Nansen was already embarked on his North Polar expedition.

All the while that Nansen was delving into whales, or pursuing the nerve fibres of the minute *Myxine glutinosa*, another great exploratory venture had been taking shape in his restless mind. For it was in the intervals snatched from dissection and microscopy in the University Museum that he planned and mounted the greatest of all his expeditions, intended to take him to the North Pole. By the winter of 1890, Nansen had already formulated his revolutionary plan of drifting through the Polar basin with the pack-ice, for observations made during his Greenland expedition had convinced him that an ocean current flowed slowly from one side of the Arctic Ocean to the other, and so would carry a ship right across the polar regions. The essential requirement was a new kind of ship that would ride up in the grip of the pack-ice, and so avoid being crushed; and therefore Nansen, undeterred by the violent objections to his theory voiced by Norwegian and English geographers, set to work and designed the " Fram " for this purpose. All the plans and drawings necessary for the construction of the vessel were made by Nansen himself; and, with the aid of the shipwright Colin Archer, its building was completed by the end of 1892. Every aspect of the project was planned with meticulous care under Nansen's supervision, for he was prepared to take five years over the journey; and in June 1893 the " Fram "—packed with scientific equipment of every description—set sail with Nansen and twelve others on board, to disappear into the frozen wastes of the North Polar Sea. Nothing more was heard of her for three long and anxious years, until Nansen and his men returned in triumph to Norway at the end of 1896.

Although the primary object of the expedition—to reach the North Pole—was not achieved, it remains one of the great epics of Arctic exploration. Not only that, but the scientific value of the multitude of observations made by the members of the expedition was enormous.

Nansen's theory of the ocean current through the polar basin was confirmed by the drifting of the ice-bound " Fram " to a longitude of 134° W; and Nansen and Hjalmar Johansen, setting off from the " Fram " in March 1895 after she became locked in the pack-ice, sledged north to a latitude of 86° 14′ N—which was 200 miles nearer the Pole than anyone had yet reached.

On his return, Nansen was appointed Professor of Zoology in the University. He was now thirty-five years of age, and internationally famous. The University excused him from all teaching duties so that he might devote himself to research, and also fulfil the many demands for lectures that were now made on him from scientific societies all over the world. Nansen therefore set to work preparing the reports of the " Fram " expedition for publication; and in 1897 there appeared the two volumes of *Farthest North*, together with " *Fram* " *across the Polar Sea*, containing many illustrations from Nansen's own hand. The full scientific data were further reported in detail in six huge volumes that appeared in the years between 1900 and 1906.

Although he now occupied a Chair of Zoology, Nansen's interests had shifted from biology to the new science of oceanography, as a result of the studies of the ocean currents that he had made while on board the " Fram ", and his career as an anatomist was now at an end. Instead, the publication of the results of the " Fram " expedition quickly established him as an international authority in oceanographic science, for not only had he established the existence of the east-west current in the polar basin, but he had also discovered the existence of a ridge on the sea-bed at the entrance to the basin—known ever since as " Nansen's Ridge ". As a result, the University in 1908 changed his title to that of Professor of Oceanography. In the following year, his labours in this new field resulted in the publication (with Bjørn Helland-Hensen) of *The Norwegian Sea*, a massive and authoritative work that still remains one of the classics of oceanography. In 1912, Nansen conducted another oceanographic expedition into the Arctic Ocean with two companions, to obtain further data on the polar currents; and the results of these and later studies were embodied in *Temperaturschwankungen des Atlantischen Ozeans und in der Atmosphäre*, published in 1917 (again in conjunction with Helland-Hensen).

In the meantime, however, Nansen—by now the most famous Norwegian of his generation—began to feel that it was his duty to lend his great personal prestige to the political evolution of his country. Since 1814 Norway and Sweden, although possessed of individual parliaments, had been united as one kingdom under the Swedish Crown; but by the end of the nineteenth century, the rising tide of Norwegian nationalism was straining the Union to breaking point. In support of this movement, Nansen began in 1905 to publish a series of influential articles in the world's

Press; and at the same time he led a series of delegations to Denmark, Germany and England to secure international support for the secessionist movement. After nine months of frenzied political activity, these efforts culminated in the establishment of an independent Kingdom of Norway under King Haakon VII (formerly Prince Carl of Denmark), whose candidature had been strongly supported by Nansen. But Nansen was not allowed to retire from public life, for Norway, now in need of a diplomatic service, naturally turned to her greatest son; and in March 1906 Nansen (now aged forty-six) left for London to become the first Norwegian Ambassador to the Court of St. James's. Two years later, after playing a leading part in the negotiations for the Integral Treaty guaranteeing Norway's independence, Nansen's request to be allowed to return to the University was granted, and it was then that he took up his Chair of Oceanography.

With the outbreak of the First World War in 1914, Nansen was again drawn back into public life in the interests of his country, and his work as a scientist was at an end—but not his work for humanity, for he now began what many regard as the greatest phase of his remarkable career. In 1917, he headed a diplomatic mission to Washington to negotiate an improvement in the shipment of food to blockaded Norway; and finally, in 1919, he was appointed leader of the Norwegian delegation to the League of Nations at Geneva. Although he had been elected as Rector Magnificus of the University on his return from Washington in 1918, Nansen was never again allowed to retire into the seclusion of university life, and until his death in 1930 he devoted himself unremittingly to the causes of international co-operation and humanitarianism.

During his ten years at the League of Nations, the League made superhuman demands upon him, none of which Nansen failed to meet. Appalled by the devastation and suffering to which the War had given rise, Nansen rose nobly to the occasion in organizing international relief on a vast scale. The creation of the Nansen Aid Organization effected the repatriation of half a million prisoners of war by 1921; while, with the aid of the Nansen passport for stateless persons, the resettlement of a million refugees from the Russian Revolution was secured in a host of different countries under Nansen's direction. The International Red Cross then turned to Nansen for help in organizing relief for the millions of starving peasants in famine-stricken Russia, and he set off into Siberia to supervise this personally. This was followed by a request from the Greek government to undertake the succour of the one and a quarter million refugees from the Graeco-Turkish War of 1922; and in 1924, the League of Nations handed Nansen the task of finding a solution to the problem presented by the thousands of Armenian refugees fleeing from the Turks.

In 1922, Nansen's humanitarian efforts, and his work for international understanding and cooperation, were recognized by the award of the

Nobel Peace Prize. Few of the recipients of this high honour have so richly deserved it; for, as a later recipient of the Prize (Viscount Cecil of Chelwood) has said, " It was, without doubt, a special élite the nations sent to Geneva. But among them all Fridtjof Nansen distinguished himself as a very embodiment of international peace and justice." Four years later, it is of interest to note, Nansen was elected by the students of St. Andrews University as their Rector.

But the years of ceaseless toil, political struggle and far-flung travel could not but affect even Nansen's hardy frame. In 1928, at the age of sixty-six, he had a mild heart attack while on a hunting trip; and two years later, after a trip into the mountains, he developed thrombophlebitis in one leg that gave rise to a pulmonary embolus. In May 1930 Fridtjof Nansen died; and his funeral took place from his old University on 17th May—on Norwegian Independence Day, commemorating the emergence of the modern Kingdom of Norway that Nansen had done so much to help create.

Nansen and neuro-anatomy

From this condensed account of Nansen's tumultuous and many-sided career, it is abundantly clear that his work in neuro-anatomy is but a minor facet of his life in general, and of his scientific activity in particular. Overshadowed by his great contributions to Arctic exploration, to oceanography, and—not least—to humanitarianism, his neurological studies seem to pale into insignificance. It is not then surprising that nothing is heard nowadays of Nansen the neuro-anatomist. But Nansen's contributions to comparative anatomy in general, and to neuro-anatomy in particular, should not be allowed to become submerged in the legend of Nansen the explorer or of Nansen the humanitarian; and in this year of the centenary of his birth, when so many of his other activities are being commemorated, it seems appropriate to call attention to his neurological work before it is irretrievably lost.

In men of lesser breed, even one major scientific achievement is rare in a lifetime of toil; but with Nansen, there were two such contributions to anatomy—in addition to his epoch-making work in geography, oceanography, meteorology and geology. Furthermore, Nansen's first major contributions to anatomy—his study of the *Myzostomae*, and of the neuro-histology of *Myxine glutinosa*—were made before he was twenty-five, and before he had even taken a university degree. His second major anatomical contribution—the massive study of the embryology and structure of the whale—was completed by the time he was thirty-three, when he had already left in the " Fram " for the icy wastes of the Arctic, and only six years after he had received his Ph.D. degree in Zoology.

Nansen in his later years once said: " The old beaten tracks do not take us to our goal. . . . Try not to waste your time in doing things which you know can be done equally well by others. Everyone should hit upon his own trail. . . . The first great thing is to find yourself." And it was in the Bergen Museum that Nansen first found himself scientifically, by doing something new. When he obtained his Curatorship in 1882, microscopy was just beginning to be an important technique in zoology and comparative anatomy; while in neurology, the great controversy over the neurone doctrine lay just beyond the horizon. Furthermore, it was only nine years since Camillo Golgi had discovered his technique for silver impregnation of nerve tissue, the use of which allowed histologists for the first time to study the morphology of nerve cells and to trace their connections within the central nervous system. Nansen " hit upon his own trail " by realizing the significance of these technical developments for comparative anatomy, so that he was the first worker to apply silver impregnation methods to the microscopic study of lower vertebrates, thereby making contributions of fundamental and permanent importance to comparative neuro-histology. These contributions are described in the various articles by Nansen listed at the end of this Note.

In his earlier papers, covering the period from his appointment at the Bergen Museum to his departure for Italy in 1886, Nansen described his studies of the cells and fibres in the central nervous system of Ascidians and of *Myxine glutinosa*. Following his return from Italy, with his histological methods improved by his experience in Naples and by his work with Golgi, Nansen elaborated these studies, paying special attention to the cells in the dorsal root ganglia and to the distribution of their central processes within the spinal cord. Applying the Golgi techniques to the nervous system of *Myxine glutinosa*, Nansen made numerous histological studies of the origin of the dorsal root fibres from the cells in the dorsal root ganglia, and traced their central branches into and within the spinal cord (Fig. 2). As a result, in his Ph.D. thesis of 1888 Nansen was the first to describe the fact that each dorsal root fibre, on entering the spinal cord, bifurcates in **T**-shaped fashion into ascending and descending branches that run intersegmentally through the neuraxis (" Nansen's fibres "), giving off collateral segmental branches to the cells in the spinal grey matter throughout their longitudinal course. This distribution is shown in Figure 2, which is a photograph of one of the nine lithograph plates in Nansen's published thesis, all of which were prepared by Nansen himself.

This discovery became of fundamental importance in neurological science for, after its confirmation by Ramón y Cajal in 1889, it provided the anatomical basis for Sherrington's classic study of intersegmental spinal reflexes. In his book *The Integrative Action of the Nervous System*, published in 1906, Sherrington refers to Nansen's work in this connection;

and within a few more years anatomists had established that Nansen's description was applicable to the vertebrates in general. These extensions of Nansen's work were described by Edinger in 1911 and by Stephen Ranson in 1912.

Nansen's later neuro-anatomical papers, which describe the studies made in the interval between his return from Italy in 1886 and his departure for the Polar Sea in the " Fram " in 1893, deal with many other aspects of the neuro-anatomy of primitive vertebrates, and constitute an important chapter in the story of the comparative anatomy of the nervous system.

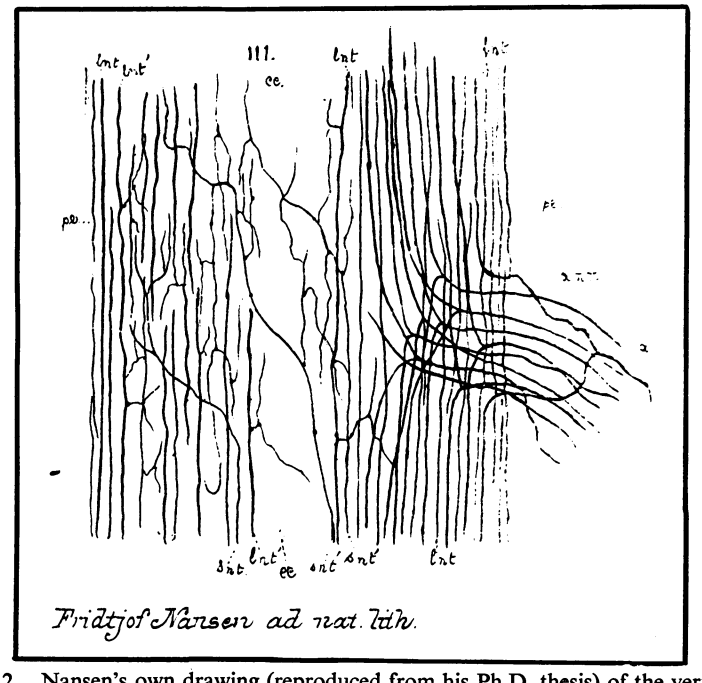

Fig. 2. Nansen's own drawing (reproduced from his Ph.D. thesis) of the vertical dichotomy of the nerve fibres of the dorsal spinal nerve root (seen on the right) as they enter the spinal cord. The lithograph was prepared by Nansen himself.

The last of these publications appeared in 1895, while Nansen was in fact locked with the " Fram " in the polar pack-ice, drifting through the Arctic Ocean at latitudes farther north than man had yet reached. It is in this paper, however, that Nansen described—again for the first time —the mixture of bipolar and unipolar neurones (" cells of Nansen ") that is characteristic of the dorsal root ganglia of fishes and other lower vertebrates. Subsequently confirmed and extended by Ramón y Cajal in 1899, this observation became of fundamental importance in the study of the comparative anatomy and embryology of the dorsal root ganglion cells.

Although, regrettably, little is heard nowadays of Nansen's contributions to the anatomy of the nervous system, his great contemporaries in neurological science were quick to appreciate their significance. Thus Gustaf Retzius, the great Swedish anatomist, said of Nansen's earlier work in neuro-anatomy: " It is indisputable that Fridtjof Nansen, in the brief period of barely five years—a period which must be regarded as unusually slight and limited—has performed a significant achievement within this science." Likewise, Nansen's findings are described in the classic works in neuro-anatomy published at the end of the nineteenth century —for example, in Déjerine's *Anatomie des centres nerveux* (1895); in van Gehuchten's *Anatomie du système nerveux de l'homme* (1897); and in Ramón y Cajal's immortal *Textura del Sistema Nervioso del Hombre y de los Vertebrados* (1899). As mentioned already, Sherrington used Nansen's observations in interpreting his studies on spinal reflexes that are described in *The Integrative Action of the Nervous System* (1906). Later, Ariëns Kappers, Carl Huber and Elizabeth Crosby included Nansen's studies on *Myxine glutinosa* in the account of the comparative anatomy of the spinal cord in their authoritative *Comparative Anatomy of the Nervous System of Vertebrates* (1936). Modern neurological texts seldom mention Nansen's work—although there is a brief reference to him in a " Historical Note " in the last edition of John Fulton's *Physiology of the Nervous System* (1949). It is hoped that this short article may help to remedy the contemporary neglect of the neurological work of one of the most remarkable men of modern times.

With the aid of Miss Jessie Dobson, Curator of the Hunterian Museum, and of Mr. W. R. Le Fanu, Librarian of the College, a small exhibition has been arranged in the College to commemorate Nansen's work in neurology.

A CHRONOLOGICAL LIST OF FRIDTJOF NANSEN'S PUBLICATIONS IN NEURO-ANATOMY

Bidrag til Myzostomernes Anatomi og Histologi. Bergen Museum: Bergen (1885).

Foreløbig Meddelelse om Undersøgelser over Centralnervesystemets histologiske Bygning hos Ascidierne samt hos *Myxine glutinosa*. *Bergens Museum Aarsb. for* 1885 (1886).

Preliminary communication on some investigations upon the histological structure of the central nervous system in the *Ascidia* and in *Myxine glutinosa*. *Ann. Mag. Nat. Hist. London* (1886), **18**, 209–226.

The structure and combination of the histological elements of the central nervous system (Ph.D. thesis). *Bergens Museum Aarsb. for* 1886 (1887), pp. 27–215.

Anatomie und Histologie des Nervensystemes der Myzostomen. *Jenaische Zeitschr. Naturwiss., Jena* (1887), **14**, 267–321.

Nerve-elementerne, deres Struktur og Sammenhäng i Centralnervesystemet. *Nord. med. Ark., Stockholm* (1887), **19**, 1–24.

Die Nervenelemente, ihre Struktur und Verbindung im Centralnervensystem. *Anatomischer Anz., Jena* (1888), **3**, 157–169.

The structure and combination of the histological elements of the central nervous system. *Bergens Museum Aarsb. for* 1895 (1896).